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RAILROAD WATER SUPPLIES IN MINNESOTA.

By R. H. MULLIN, Director, H. A. WHITTAKER, Assistant Director, and B. M. MOHLER, Chemist, Laboratory Division of the Minnesota State Board of Health.

On January 25, 1913, the Secretary of the Treasury, under authority of an act of Congress approved February 15, 1893, promulgated the following regulation regarding the water and ice furnished to passengers by common carriers in interstate traffic:

AMENDMENT TO INTERSTATE QUARANTINE REGULATIONS.

Article 3, General Regulations, is hereby amended by the addition of the following paragraph:

"Paragraph 15. Water provided by common carriers on cars, vessels, or vehicles operated in interstate traffic for the use of passengers shall be furnished under the following conditions:

"(*a*) Water shall be certified by the State or municipal health authority within whose jurisdiction it is obtained as incapable of conveying disease: *Provided*, That water in regard to the safety of which a reasonable doubt exists may be used if the same has been treated in such manner as to render it incapable of conveying disease, and the fact of such treatment is certified by the aforesaid health officer."

This regulation was brought to the attention of the secretary and executive officer of the Minnesota State Board of Health and considered at the April meeting of the board. It was then decided that in order to have a uniformity in results and to have the work done by trained observers, a survey of such water supplies should be undertaken by the Minnesota State Board of Health and reported to the Surgeon General of the United States Public Health Service to enable the railroads to conform with the regulation. Further it was decided to extend the scope of the work to include not only interstate traffic, but also intrastate traffic, in this way adding a further protection to the citizens of this State, who may be engaged in travel solely within its boundaries. This work was assigned by the board to the laboratory division. The field work was undertaken by H. A. Whittaker, and the analytical examinations were made by him and B. M. Mohler. All drawings in this report were made by the engineering division.

In order to conserve time and expense in traveling, circular letters were written to every railroad operating in Minnesota calling their attention to the regulation and to the fact that the State board of health was about to undertake the work for them. Each railroad was asked to submit a list of the localities from which water was taken for drinking purposes on its particular trains. With few exceptions, the railroads willingly cooperated in this work and promptly furnished the desired information. As soon as all the replies were obtained, the different localities were listed and divided into districts in order that the greatest number of places could be visited in any one district with the smallest amount of travel. Owing to a State law the board was unable to accept transportation for its representative during these investigations, which had been offered by several of the railroad companies, so that the entire expense, not alone for mileage traveled during the investigation, but for the shipment of the field equipment and all other expenses, has been carried by this board.

From the replies received from the railroad companies, 66 localities were placed upon the list as requiring investigation. However, while the investigation was in progress, it became apparent that in 6 instances erroneous information had been supplied, thereby eliminating the necessity of investigating these localities. The 60 remaining localities are listed below, and in addition there is shown at each locality what particular railroad or railroads obtain their water supplies at that point. It will be noted that in this list the cities of Minneapolis and St. Paul are omitted. This omission is intentional, inasmuch as both cities have trained men and municipal laboratories at their disposal and should be competent to pass upon the suitability of the supplies within their city limits. The water of the city of Minneapolis is treated by filtration and subsequent hypochlorite treatment and has received numerous intermittent checks in this laboratory, in addition to continuous daily checks carried out in laboratories maintained by the city of Minneapolis.

TABLE 1.

No.	Locality.	Railroad.
1	Albert Lea	C., R. I. & P.
2	Barnesville	G. N.
3	Bemidji	Do.
4	Biwabik	D. &. I. R.
5	Brainerd	N. P.
6	Breckenridge	Do.
7	Browns Valley	G. N.
8	Chatfield	C. & N. W.
9	Cloquet	D. & N. E.
10	Coleraine	D., M. & N.
11	Crookston	G. N.
12	Currie	C., St. P., M. & O.
13	Deer River	M. & R. R.
14	Duluth	C. N.; C., St. P., M. & O.; D. & I. R.: D., M. & N.; G. N.; M., St. P. & S. Ste. M.; N. P.
15	East Grand Forks	N. P.
16	Ellsworth	C., R. I. & P.
17	Elmore	C., St. P., M. & O.
18	Ely	D. & I. R.
19	Eveleth	Do.
20	Eyota	C. & N. W.
21	Glencoe	C., M. & St. P.
22	Glenwood	M., St. P. & S. Ste. M.
23	Grand Rapids	G. N.
24	Hayfield	C. G. W.
25	Hull Rust Yards	D., M. & N.
26	Jasper	C., R. I. & P.
27	Knife River	D. & N. M.
28	Little Falls	N. P.
29	Mankato	C. & N. W.; C., St. P., M. & O.
30	Mitchell	D., M. & N.
31	Montevideo	C., M. & St. P.
32	Morris	G. N.: N. P.
33	Mountain Iron	D., M. & N.
34	New Ulm	C. & N. W.
35	Northfield	C., M. & St. P.
36	Ortonville	Do.
37	Pipestone	C., St. P. M. & O.
38	Plainview	C. & N. W.
39	Pokegama Springs	N. P.
40	Rainy Junction	D., M. & N.
41	Redby	M. R.; L. & M.
42	Redwood Falls	C. & N. W.
43	Rochester	C. G. W.; C. & N. W.
44	Rush City	N. P.
45	St. James	C., St. P., M. & O.
46	Sanborn	C. & N. W.
47	Sandstone	G. N.
48	Sleepy Eye	C. & N. W.
49	Staples	N. P.
50	Stillwater	C., St. P., M. & O.
51	Tracy	C. & N. W.
52	Two Harbors	D. & I. R.
53	Vesta	C. & N. W.
54	Virginia	C. N.; D., M. & N.; G. N.
55	White Bear	N. P.
56	Willmar	G. N.
57	Winona	C. & N. W.
58	Worthington	C., St. P., M. & O.; C., R. I. & P.
59	Wyoming	N. P.
60	Zumbrota	C. & N. W.

Method of Conducting the Investigations.

In conducting this series of investigations it was decided to follow the regular routine methods which have always been in operation in the laboratory division of the State board of health with regard to the proper investigation of drinking-water supplies. It has been the custom of the State board of health in its routine work on water supplies to insist that the investigation shall be composed of two distinct parts—(1) a field investigation; (2) an analytical investigation. These investigations are undertaken by members of the laboratory staff, whose duties are confined largely to this work. By having one observer wholly responsible for each investigation it is possible to obtain a proper correlation between the field and analytical data, thereby insuring greater accuracy in the final results.

Experience has shown that the sooner analytical examinations are begun after the collection of samples the more accurate will be the final determinations. This is especially true of the work on the bacteriological side, on account of the alteration in the bacterial population of a water which spends indefinite lengths of time in transit, when shipped to a laboratory for examination, during which it is subject to varying conditions. For this reason a field outfit for the collection of bacteriological samples of water has been devised. This outfit has undergone a process of evolution until finally one very satisfactory for the purpose has been obtained. A complete description of the final outfit has not as yet been published, although various modifications which have been used during the last 10 years have been described from time to time.[1]

The outfit as used at present (fig. 1) is made of ½-inch basswood, the front and back being three-ply cross laminated to prevent warping. The front opens on strap hinges at the bottom, providing, when open, a fairly satisfactory bench for laboratory purposes. The cover has a carrying handle such as is ordinarily supplied by trunk manufacturers. It opens on strap hinges at the back and carries in front a hinged hasp which fits over a staple and can be securely fastened with a padlock. The free edges are protected with chain irons. The corners and edges are further protected with iron trunk corners. The case is stained inside and out with a simple oak stain. The inside of the case is divided into compartments of a size adapted to the contents which they are intended to hold, as shown in the perspective, figure 2. Detailed drawings giving the exact dimensions are shown in figures 3 and 4. The case packed for shipment is shown in figure 5. In the lower left-hand compartment is placed a Barthel alcohol lamp, inverted over which is a copper

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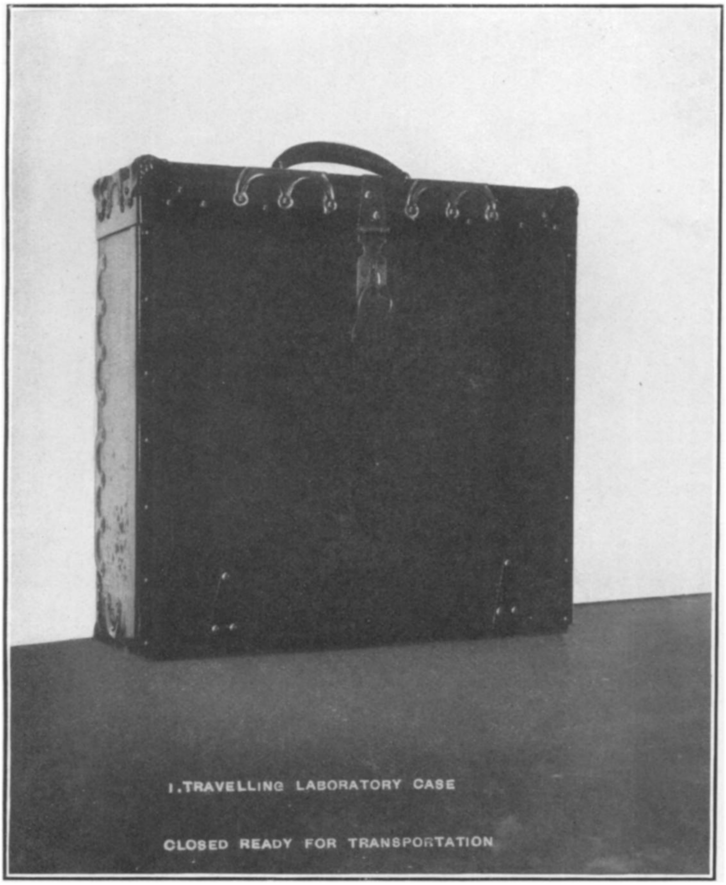
[1] Journal of Infectious Diseases, Supplement No. 1, May, 1905, pp. 304–324. U. S. Dept. of Agriculture, Bureau of Plant Industry, Bulletin No. 154, 1909, pp. 18.

Public Health Reports, May 15, 1914.



1. TRAVELLING LABORATORY CASE

CLOSED READY FOR TRANSPORTATION

FIG. 1.

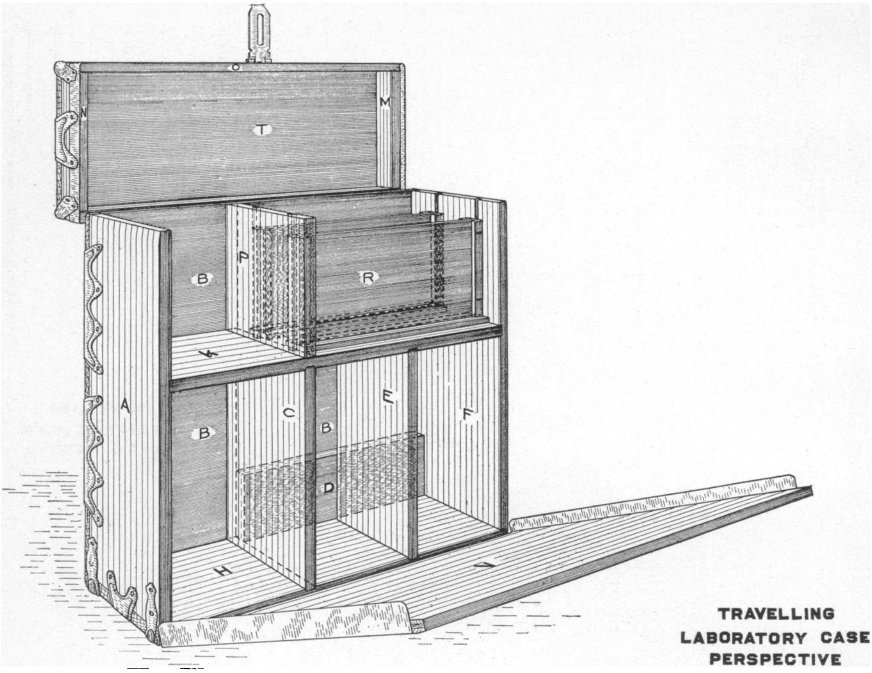

T
N
M
B
P
R
K
A
B
C
B
E
F
D
H
V
TRAVELLING
LABORATORY CASE
PERSPECTIVE

FIG. 2.

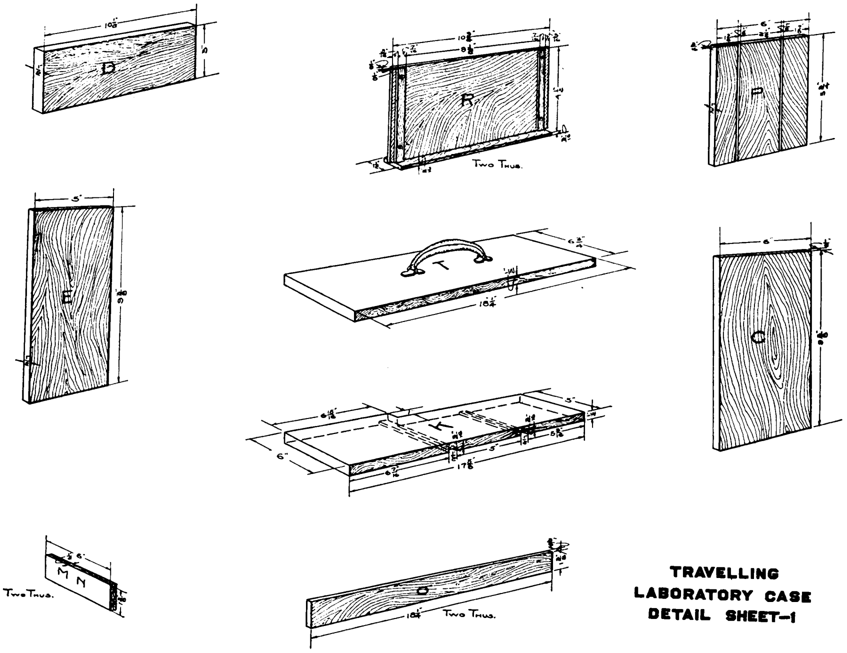

D
R
Two Thus.
P
E
T
C
K
M N
Two Thus.
O
Two Thus.
TRAVELLING
LABORATORY CASE
DETAIL SHEET—1

FIG. 3

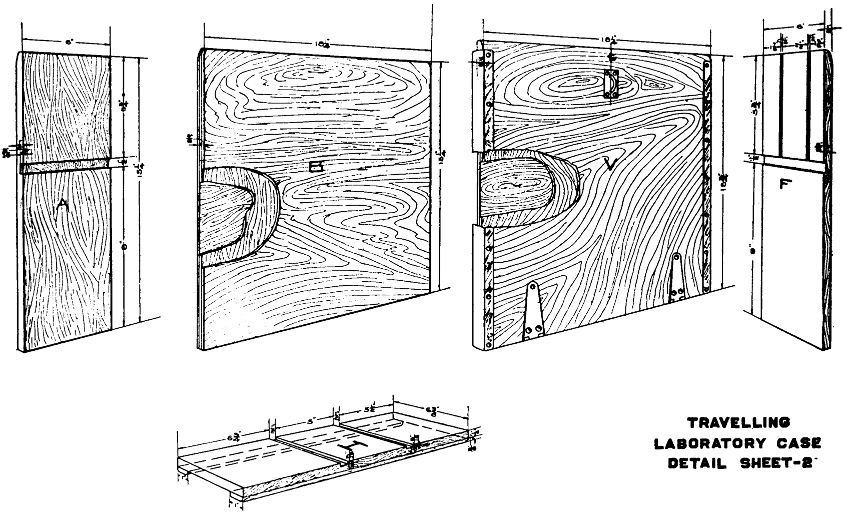

A
B
V
F
H
TRAVELLING
LABORATORY CASE
DETAIL SHEET-2

FIG. 4.

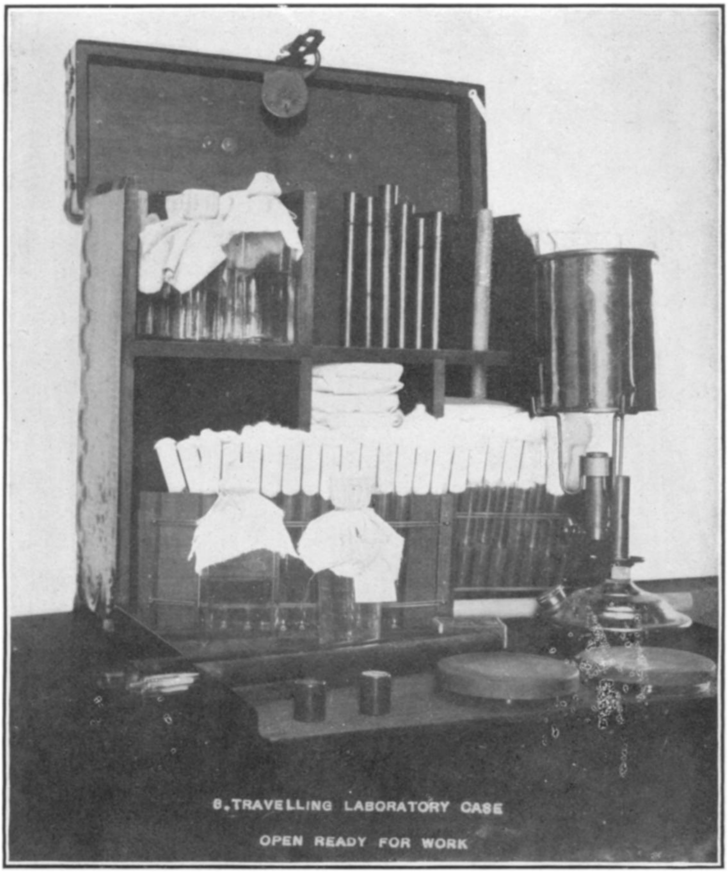

6. TRAVELLING LABORATORY CASE
OPEN READY FOR WORK

FIG. 5.

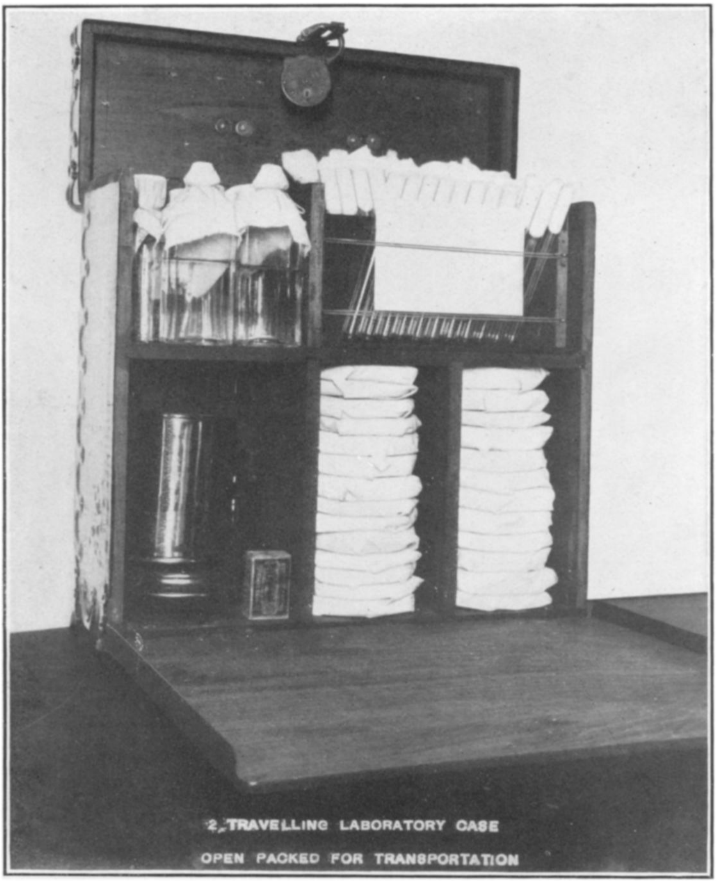

2. TRAVELLING LABORATORY CASE
OPEN PACKED FOR TRANSPORTATION

FIG. 6.

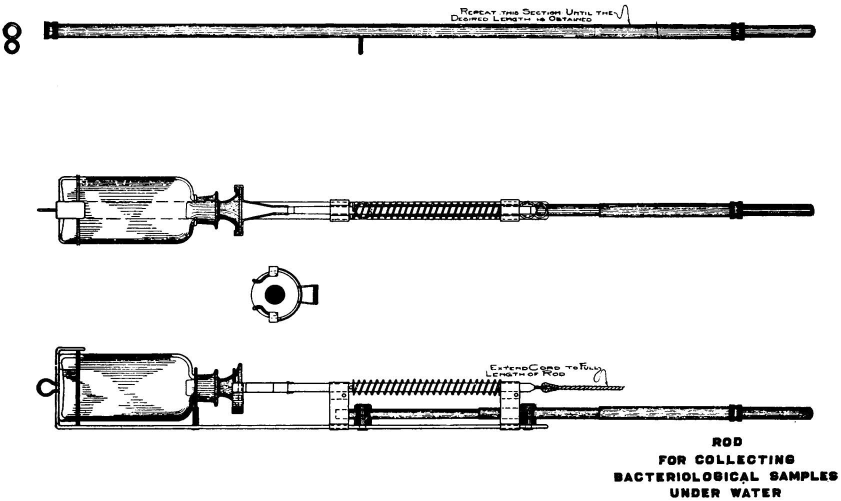

Repeat this Section Until the Desired Length is Obtained
Extend Cord to Full Length of Rod
ROD
FOR COLLECTING
BACTERIOLOGICAL SAMPLES
UNDER WATER

FIG. 7.

dish 4 inches in diameter and 5 inches high, used for boiling the water when liquefying the agar. This dish, when in use, is held over the lamp by means of a tripod, as shown in figure 6. An additional supply of alcohol in an 8-ounce bottle may be placed in this compartment. The contents are held securely by being packed with towels. The other two lower compartments carry each 11 Petri dishes of the porous-top variety, each capsule being separately wrapped in filter paper to prevent breakage in transit.

In the upper left-hand compartment are placed six 4-ounce XX ware ground-glass-stoppered sampling bottles (these are graduated to show 100 cubic centimeters capacity), and two dilution water bottles of 6-ounce capacity, rubber-stoppered. All of these bottles are previously sterilized after being capped with cotton, which is securely fastened around the neck by a string. The upper right-hand compartment holds two test-tube racks held in position by being provided with a tongue fitting into a vertical lateral groove. Each rack will carry 24 test tubes, which are held in position by rubber bands stretched between two projecting screws. One rack holds the agar for plating and the other sterile test tubes for dilution, when required. Behind this compartment is a sixth compartment for holding pipettes and thermometers. The thermometers are carried in the wooden tubes ordinarily supplied by the manufacturer. The pipettes are carried in brass tubes $\frac{3}{4}$ inch in diameter and $12\frac{1}{2}$ inches long, provided with a tightly fitting cap. Four 1-cubic-centimeter pipettes delivering that amount and graduated in tenths, or one 10-cubic-centimeter pipette delivering that amount graduated in cubic centimeters and tenths, can be placed in each brass case. Data blanks are placed in the front test-tube rack. Matches, lead and wax pencils, shipping tags, labels, chalk, and extra rubber bands are placed in an envelope between the two test-tube racks. Figure 6 gives a more detailed idea of the contents of the case.

Field Investigations.

In a proper and accurate investigation of a given water supply, information derived from a field investigation is of the utmost importance if an exact sanitary determination of the value of the supply is to be obtained. It is obvious that an analytical examination will yield information concerning the supply applicable only to the particular time at which the sample is collected. A field investigation, on the other hand, will afford opportunities for determining the probability and possibility of pollution gaining entrance to the water supply, and will, therefore, enable an observer to give a more authoritative opinion concerning the safety of that water supply. It further affords an opportunity to make recommendations for the elimination of errors in the location, environment, construction, or management of a given water supply, thereby affording the parties operating the supply an opportunity for putting it into a safe and sanitary condition. It is impossible to obtain such a result from a bacteriological examination alone. It is for these reasons that the Minnesota State board of health has always insisted upon a field examination made by a trained observer in its routine work on water supplies. To give an idea of the extent of the examination made in the field, the following outline is given, which is used as a basis for field investigations. By always following such an outline comparable information concerning different supplies may be obtained for statistical purposes. This outline is of such a character that it can be expanded at any point necessary to complete the description of any given water supply, and so may be made applicable to the conditions at any locality.

INSPECTION DATA ON WATER SUPPLIES.

1. Identification data:
    - A. Date of visit.
    - B. Ownership—private or public.
    - C. Location—
        - (1) Rural—Range, county, township, section, etc.
        - (2) Urban—City, town, village, street number, etc.
    - D. Size of site—Square miles, acres, or feet.
    - E. Use of site—Residence, manufacturing, farming, etc.
    - F. Sketch—
        - (1) Topography—Character of surface, drainage, etc.
        - (2) Location of—Water supply, buildings and factors affecting quality of water supply.
    - G. Photographs—Cases of unusual interest.
2. Local and structural water data:
    - A. Source of water supply—
        - (1) Wells—
            - (*a*) Location.
            - (*b*) Type.
            - (*c*) Depth.
            - (*d*) Strata.
            - (*e*) Casing.
            - (*f*) Well pit (casing and dimensions).
            - (*g*) Covering.
            - (*h*) Method of drawing water.
            - (*i*) Yield.
            - (*j*) Permanence of supply.
            - (*k*) Use.
            - (*l*) Abandoned wells.
            - (*m*) Sanitary aspect (environment and defects in structure and operation), etc.
        - (2) Cisterns—Same as (1) omitting (*f*) and substituting capacity for (*c*).
        - (3) Springs—Same as (1) omitting (*c*) and substituting spring pit for well pit in (*f*).

2. Local and structural water data—Continued.
    - A. Source of water supply—Continued.
        - (4) Rivers—
            - (*a*) Name.
            - (*b*) Source.
            - (*c*) Size.
            - (*d*) Character of basin—Topography, geology, populated, etc.
            - (*e*) Contaminating factors—Sewage, trade wastes, etc.
            - (*f*) Use of water.
            - (*g*) Method of drawing water.
            - (*h*) Local sanitary aspect.
        - (5) Lakes same as (4).
        - (6) Ponds same as (4).
    - B. Storage of water supply—
        - (1) Reservoir or tank—
            - (*a*) Location.
            - (*b*) Structure (wood, steel, concrete, etc.).
            - (*c*) Capacity.
            - (*d*) Elevation.
            - (*e*) Covering.
            - (*f*) Gravity or pressure distribution.
            - (*g*) Sanitary aspect—
                - When cleaned last and how.
                - Decomposition of structure in contact with water.
                - Character of sediment on bottom or sides.
    - C. Distribution system of water supply.
        - (1) Length and size of mains or piping system.
        - (2) Number of hydrants and taps.
        - (3) Sanitary aspect—
            - (*a*) Relation to sewer system, cesspools, etc.
            - (*b*) Sediment in pipes.
            - (*c*) Previous or present infection of system.
            - (*d*) Previous or present disinfection of system.
            - (*e*) Other sources connected for fire protection.
    - D. Consumption of water—
        - (1) Average and maximum daily consumption.
        - (2) Number of people supplied.
        - (3) Per cent of total number.
    - E. Sampling points—
        - (1) Exact location.
        - (2) Reasons for selecting these points.

Sampling Methods.

During the progress of this investigation two kinds of samples as a rule were collected on each water supply, one for a bacteriological and one for a physical and chemical examination. In obtaining a sample for bacteriological examination it is essential that a fair and representative sample should be obtained. It is customary, therefore, to collect samples from the source and from the distribution system as required. Under certain conditions it is necessary to collect samples from various depths, and for this purpose a sampling rod was devised by Dr. H. W. Hill when assistant director of this laboratory. This rod based on the principle of a jointed fishing rod is made of one-half inch brass tubing cut in 2-foot lengths so as to fit an ordinary suitcase. Any number of lengths may be provided. In addition there is a special device of simple design for removing and replacing the glass stopper by means of a stout cord when the desired depth is reached (see fig. 7). In collecting samples for a bacteriological examination the 4-ounce, glass-stoppered bottle is used. In collecting samples for a physical and chemical examination a 1-gallon, glass-stoppered bottle is employed. For the latter a shipping case has been devised made of the same material as the bacteriological case, but holding two bottles only. Accompanying each sample there is a data blank of the following form:

LABORATORY DIVISION.

MINNESOTA STATE BOARD OF HEALTH.

WATER AND SEWAGE SAMPLE DATA CARD.

Spec. No...

Material Collected...

Town. Etc...

Map Location...

Specific Location...

Source of Material...

Collected by...

Date and Hr. Coll...

Temp.................1. Air.......................2. Water...

Kinds of Samples...

Date and Hr. Plated...

Plated by...

Date and Hr. Shipped...

Date and Hr. Rec'd...

Map Location—Street, No., Etc., of house, pumping station, etc.
Specific Location—Name and place of well, faucet, etc., i. e., relative position to house, etc.
Material Collected—Nature of sample, i.e., water or sewage.
Source of material—City Supply, River, Private well, etc.

Analytical Investigations.

Bacteriological examination.—The bacteriological methods which are employed are those recommended by the committee on standard methods of water analysis of the American Public Health Association, with the following exceptions:

(1) Incubation was at room temperature and for four days from time of plating. If less than four days were established as a limit, plates would often be received in the laboratory so long after plating that the allowed incubation period would already have been exhausted in transit.

(2) The colon tests recommended alternatively as procedure A and procedure B by the committee on standard methods of water analysis of the American Public Health Association were both employed, the former on 100 cubic centimeter samples enriched

by quadruple strength broth and incubated; the latter on 1 cubic centimeter samples prepared in the field, which is also an enrichment method.[1]

(3) The preparation of media followed strictly the committee's recommendations except in the following details:

Artificial milk.—Owing to variability of ordinary milk the substitute described in Vol. II, No. 3, March, 1912, p. 162 of the American Journal of Public Health by H. A. Whittaker was used.

(4) The order of procedure in the adjustment of acidity in nutrient agar and gelatin media was slightly changed.[2]

(5) From all the dilutions made those plates were selected which yielded counts of not much much above 200, all that were higher being disregarded.

The work is commenced in the field by pouring plates, using 1 cubic centimeter and 0.1 cubic centimeter amounts, making dilutions where the field investigation indicates their necessity. At the same time 1 cubic centimeter of the water is mixed with from 1 to 2 cubic centimeters of molten agar at a temperature of 40° C. and allowed to cool. This is called an "agar shake" and provides for the protection and development of *B. coli* when present. The case is then repacked and shipped to the laboratory. There the agar shake is broken up with a twisted, sterilized, aluminum wire and emptied into a lactose broth fermentation tube for the isolation of *B. coli* in 1 cubic centimeter amounts where the presumptive test indicates its presence.

Physical and chemical examination.—All physical and chemical examinations are made following exactly the standard methods mentioned above.

Detailed sheets for the bacteriological, chemical, and physical, and a summary sheet are employed, the forms of each being shown here.

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[1] Westbrook, F. F. Laboratory methods and devices. Journal of Infectious Diseases, supp. No. 1, pp. 322-323. 1905.

[2] Hill, H. W. Suggestions for changes in the schedules for making broth, gelatin, and agar, etc. Journal of Infectious Diseases, supp. No. 2, pp. 223-225. February, 1906.

Water and sewage bacterial detail sheet.

MINNESOTA STATE BOARD OF HEALTH.

LABORATORY DIVISION.

Details of bacterial examination of..............................

Town, etc..........................Specific location..

Map location..........................Source..

Specimen No. ...... Date examined .... Examined by............................

Bacterial count= per cc. Date counted...............

Amnt.	Amnt.	Amnt.	Amnt.	Count.	Medium.	Temp.	Time.
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....

Bacillus coli = in 1 cc. *Bacillus coli* = in 100 cc.

Preliminary cultivation.

Medium.	Date.	Remarks.	Medium.	Date.	Remarks.
Agar Shake	......	....	Broth and Water	......	....
Result	......	....	Result	......	....
A. S. Ferm. Tube	......	....	B. Ferm. Tube	......	....
Result	......	....	Result	......	....
A. S. F. T. Plates	......	....	B. F. T. Plates	......	....
Result	......	....	Result	......	....
Replates	......	....	Replates	......	....

Cultures isolated.

Pure Cultures.	A.	B.	C.	D.	E.	F.	G.	Pure Cultures.	1	2	3	4	5	6	7
L. L. Agar; Color	....	....	....	....	....	....	....	L. L. Agar; Color	....	....	....	....	....	....	....
Morphology	....	....	....	....	....	....	....	Morphology	....	....	....	....	....	....	....
Gas: Amt	....	....	....	....	....	....	....	Gas: Amt	....	....	....	....	....	....	....
Acid	....	....	....	....	....	....	....	Acid	....	....	....	....	....	....	....
$H:CO_2$	....	....	....	....	....	....	....	$H:CO_2$	....	....	....	....	....	....	....
Morphology	....	....	....	....	....	....	....	Morphology	....	....	....	....	....	....	....
Motility	....	....	....	....	....	....	....	Motility	....	....	....	....	....	....	....
S. F. Broth	....	....	....	....	....	....	....	S. F. Broth	....	....	....	....	....	....	....
Lit. Milk	....	....	....	....	....	....	....	Lit. Milk	....	....	....	....	....	....	....
Gelatin	....	....	....	....	....	....	....	Gelatin	....	....	....	....	....	....	....
Potato	....	....	....	....	....	....	....	Potato	....	....	....	....	....	....	....

Color+ = red.
Morph.+ = Bacillus, proper size and shape, without spores.
Motil.+ = slight motility, + + = marked, +++ = very rapid.
S. F. Broth+ = indol present.
Lit. Milk+ = red or decolorized, and coagulated.
Gelatin+ = no liquefaction.

Water and sewage chemical detail sheet.

MINNESOTA STATE BOARD OF HEALTH.

LABORATORY DIVISION.

Details of chemical examination of ....

Town, etc .... Specific location ....

Map location .... Source ....

Specimen number ...... Date examined .... Examined by ....

Temp. Deg. C.	Turbidity.	Color.	Odor.		Tint and shade in percentages of—				
			20° C.	90° C.	Red.	Yellow.	Blue.	White.	Black.

TOTAL HARDNESS. Amount taken=200 c. c. N/10 Soda Reagent= $N/20\ H_2SO_4$= Parts ($CaCO_3$)=	ALKALINITY. Amount taken=25 c. c. $N/50\ H_2SO_4$= Parts ($CaCO_3$)=	INCRUSTANTS. Amount taken=1000 c. c. Total Hardness= Alkalinity= Parts=	FREE AMMONIA. Amount taken= c. c. 1st 50 c. c.= 2nd 50 c. c.= 3rd 50 c. c. ..x..=Parts=
ALBUMINOID AMMONIA. Amount taken= c. c. 1st 50 c. c.= 2nd 50 c. c.= 3rd 50 c. c.= 4th 50 c. c.= 5th 50 c. c.= ..x..=Parts=	ORGANIC NITROGEN. Amount taken= c. c. 1st 50 c. c.= 2nd 50 c. c.= 3rd 50 c. c.= 4th 50 c. c.= ..x..=Parts=	TOTAL NITROGEN. Amount taken=1000 c. c. N. as Org. Nit.= N. as Free NH_3= N. as Nitrites= N. as Nitrates= Parts=	TOTAL RESIDUE. Amount taken=100 c. c. Wgt. Dish+Res.= Wgt. Dish= Wgt. Res.= Parts=
FIXED RESIDUE. Amount taken=100 c. c. Wgt. Dish+Res.= (after ignition) Wgt. Dish= Wgt. Res.= Parts=	LOSS ON IGNITION. Amount taken=100 c. c. Wgt. Total Res.= Wgt. Fixed Res.= Wgt. Res.= Parts=	SUSPENDED RESIDUE. Amount taken=100 c. c. Wgt. Total Res.= Wgt. Total Res.= (filtered) Wgt. Res.= Parts=	DISSOLVED RESIDUE. Amount taken=100 c. c. Wgt. Total Res.= Wgt. Susp. Res.= Wgt. Res.= Parts=

Determination.	Parts.	c. c. taken.	Reagents.	c. c. taken.
Nitrites.			Sulphanilic Acid. Amidonaphthalene.	
Nitrates.			Phenolsulphonic Acid. Ammonium Hydrate.	
Chlorine.			Silver Nitrate. Potassium Chromate.	
Iron.			Dilute HCL. Pot. Sulphocyanide.	
Acidity.			$N/50\ Na_2CO_3$.	
Dissolved Oxygen.			N/40 Sod. Thiosulph. Capacity of bottle.	
Oxygen Consumed.			Sulphuric Acid. Pot. Permang. Amm. Oxalate. Pot. Permang.	
Free Carbonic Acid.			$N/22\ Na_2CO_3$.	
Calcium.				
Magnesium.				
Fats.				
Putrescibility.				

MINNESOTA STATE BOARD OF HEALTH.

LABORATORY DIVISION.

Results of analytical examination of..............................

Town, etc............................ Specific location..

Map location......................... Source...

Specimen number						
Collected by						
Date collected						
Date reported						
BACTERIAL: exam. by						
Bacteria per c. c						
B. *Coli*						
PHYSICAL: exam. by						
Temperature						
Turbidity						
Color						
Tint and shade						
Odor..at 20°c: at 90°c						
CHEMICAL: exam. by						
(parts per million)						
Total hardness	W					
Alkalinity	W					
Incrustants	W					
Albuminoid ammonia	W					
Free ammonia	S. W					
Organic nitrogen 1	S. W					
Nitrites	S. W					
Nitrates	S. W					
Chlorine	S. W					
Total nitrogen	S					
Total residue	S					
Fixed residue	S					
Loss on ignition	S					
Suspended residue 2	S					
Dissolved residue	S					
Iron 5	S					
Acidity 4	S					
Dissolved oxygen 4	S					
Oxygen consumed	S					
Fats	S					
Putrescibility 4	S					
Free carbonic acid 4, 5						
Calcium 3						
Magnesium 3						

1. Except ground waters. 2. And turbid waters. 3. Softened waters only. 4. And highly polluted waters. 5. And ground waters.

Method of Reporting upon Investigation.

In the case of each water supply a formal report is prepared in which first the field data are carefully stated and discussed. The analytical data are given in the summary sheet devised for that purpose. These are followed by an interpretation of results in which the field and analytical data are co-related when possible or necessary, and the results adequately discussed. Finally, conclusions are drawn and recommendations made providing for the correction of any faults which may have been brought to light which would lead to the future protection of the water supply. Where it is apparent that the water supply in question is safe from a sanitary standpoint, a certificate to that effect is issued. Where the water supply in question appears open to the possibility of pollution, or actually shows evidence of pollution, the form of certificate indicates that such is the case and the supply is not recommended as a drinking water. The form of certificate used differs slightly from that issued by the Surgeon General of the United States Public Health Service, inasmuch as it became apparent that alterations in the latter would be necessary before it could be utilized in this State. The form used here is as follows:

MINNESOTA STATE BOARD OF HEALTH.

Capitol Building, St. Paul.

CERTIFICATE OF EXAMINATION.

This is to certify that the supply at ....
from which the .... is obtained for the use of passengers on the ....
....
has been investigated by the Minnesota State Board of Health on ....
At the time of this investigation the field survey showed conditions which are ....
.... from a sanitary aspect; in the analytical examination indications of dangerous contamination were .... found.

This .... therefore can ...... be recommended for public consumption.

....
Executive Officer.

Date, ...

It becomes necessary at once to arrive at certain standards for certification. This is a matter attended by difficulty as definite standards in this line of work are difficult to make on an absolutely numerical basis on account of the varying conditions which obtain. However, in this work it was decided that before a water supply could be recommended, it should be without objection from the following aspects: (*a*) Location, (*b*) environment, (*c*) construction. These are, of course, very general headings, and are stated not as an absolute basis but merely to give an idea of the means which are employed in arriving at a conclusion. Other factors in special cases may alter considerably the relative value of any one of these. On the bacteriological side, the absence of *B. coli* in 100 cubic centimeter amounts was required. Even in certain instances where *B. coli* was not found in 100 cubic centimeter amounts, if the count ran excessively high for water from such a source, recommendations for its use were not given. On account of the varying character of the supplies examined and the sources from which they come, it is impossible to lay down any general standards regarding the chemical or physical examinations. This is especially true as in many instances previous examinations of these water supplies had not been made so that it was impossible to make any comparisons regarding changes in the chemical or physical constituents of the water. Copies of these reports and certificates were sent, through the executive officer of the State board of health, to the party or parties operating the supply and to the railroads using that supply.

Discussion of the Results.

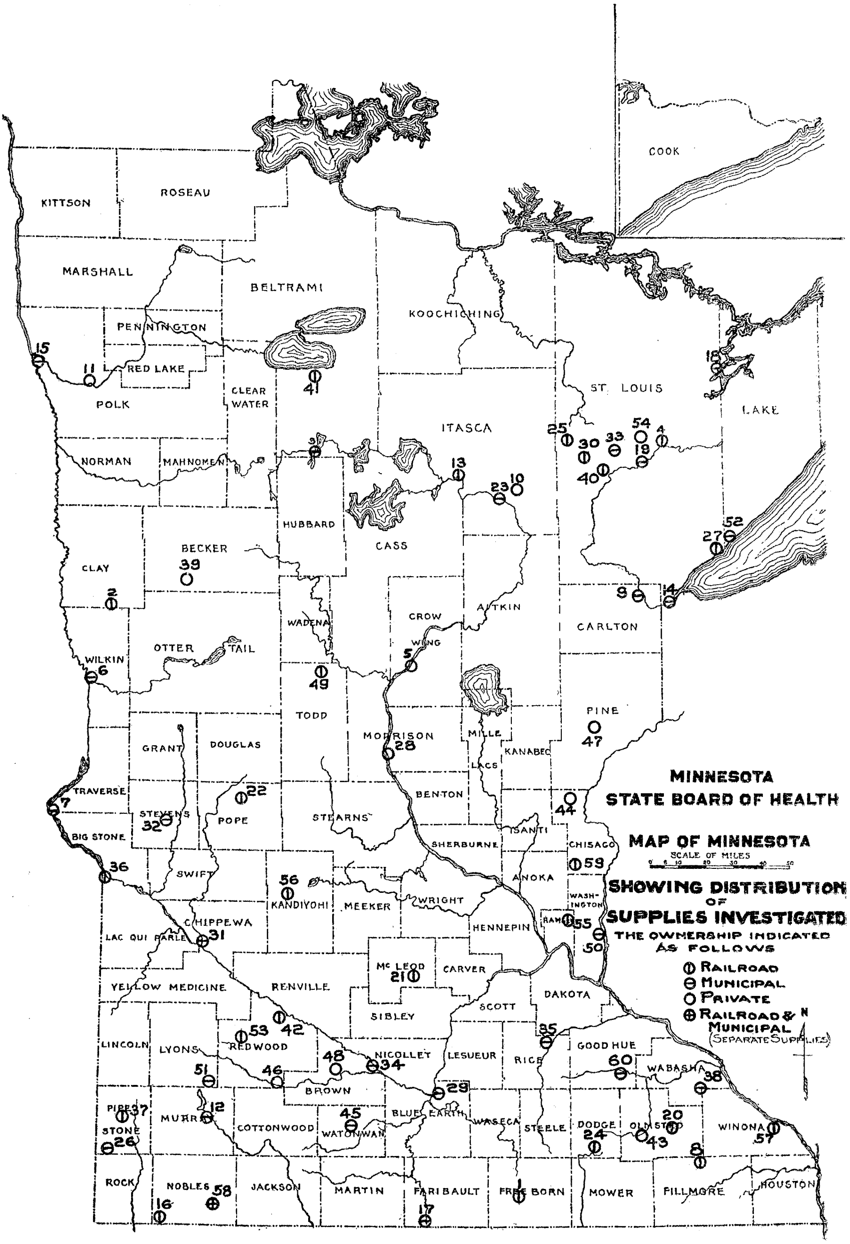
During the course of this investigation 61 water supplies were investigated at 60 of the localities visited, one locality having two different supplies which were used by different railway companies. The names of these localities and the railroads using the water supply at each have already been given. The following list will indicate the localities in this State at which water supplies were examined and reported to the respective railroads.

TABLE 2.

1. Canadian Northern—Duluth, Virginia.
2. Chicago, Great Western—Hayfield, Rochester.
3. Chicago, Milwaukee & St. Paul—Glencoe, Montevideo, Northfield, Ortonville.
4. Chicago & Northwestern—Chatfield, Eyota, Mankato, New Ulm, Plainview, Redwood Falls, Rochester, Sanborn, Sleepy Eye, Tracy, Vesta, Winona, Zumbrota.
5. Chicago, St. Paul, Minneapolis & Omaha—Currie, Duluth, Elmore, Mankato, Pipestone, St. James, Stillwater, Worthington.
6. Chicago, Rock Island & Pacific—Albert Lea, Ellsworth, Jasper, Worthington.
7. Duluth & Iron Range—Biwabik, Duluth, Ely, Eveleth, Two Harbors.
8. Duluth, Missabe & Northern—Coleraine, Duluth, Mitchell, Mountain Iron, Rainy Junction, Virginia.
9. Duluth & Northeastern—Cloquet.
10. Duluth & Northern Minnesota—Knife River.
11. Great Northern—Barnesville, Bemidji, Breckenridge, Browns Valley, Crookston, Duluth, Grand Rapids, Morris, Sandstone, Virginia, Willmar.
12. Minneapolis & Rainy River—Deer River.
13. Minneapolis, Red Lake & Manitoba—Redby.
14. Minneapolis, St. Paul & Sault Ste. Marie—Duluth, Glenwood.
15. Northern Pacific—Brainerd, Duluth, East Grand Forks, Little Falls, Morris, Pokegama Springs, Rush City, Staples, White Bear, Wyoming.
16. Minneapolis & St. Louis—No information could be obtained from this road regarding its drinking water supplies.

In order to give an idea of the geographical distribution of these localities map No. 1 has been prepared, indicating the position in the State of each locality and, in addition, the ownership of the particular supply.

It hardly seems advisable to insert the complete reports of the investigation at each locality. However, the results have been summarized and tabulated in Table 3. This table, in which the localities are arranged in alphabetical order, shows the date on which the investigation was made, the source of the supply, ownership of the supply, the sanitary condition of the supply, and there is also indicated whether a recommendation for the use of the water was given or refused. Under sanitary conditions of the supply the results obtained by field investigation and by analytical results are indicated merely. Where the field investigation is unsatisfactory, an attempt has been made to point out the nature of the principal objection by the numerals indicating, as required, an error either in the location, environment, or construction of the particular supply. In addition there is shown by the numerals, as required, whether or not in certain of the surface water supplies any form of treatment or sanitary supervision is applied.



MAP NO. 1.

A summary of the bacteriological results on each supply investigated is given in Table 4 and the results of the physical and chemical analyses are given in Table 5. These tables require no further comment.

TABLE 3.—*General summary of investigation.*

Supply No.	Locality.	Date.	Source.	Ownership.	Sanitary condition of supply as shown by—		Recommendation for use.
					Field investigation.	Analytical results.	
1	Albert Lea	Nov. 8, 1913	Drilled well	Railroad	Satisfactory	Satisfactory	Given.
2	Barnesville	Aug. 12, 1913	Whiskey Creek [1]	do	Unsatisfactory [2] [3]	Unsatisfactory	Refused.
3	Bemidji	June 12, 1913	Drilled wells	Municipal	Satisfactory	Satisfactory	Given.
4	Biwabik	June 5, 1913	Drilled well	Railroad	do	do	Do.
5	Brainerd	Aug. 11, 1913	Browns Spring	Private	do	do	Do.
6	Breckenridge	May 1, 1913	Ottertail River [4]	Municipal	do	do	Do.
7	Browns Valley	Oct. 4, 1913	Dug wells	do	Unsatisfactory [5] [3]	Unsatisfactory	Refused.
8	Chatfield	Nov. 14, 1913	Drilled well	Railroad	do.[2]	Satisfactory	Do.
9	Cloquet	July 22, 1913	Springs	Municipal	do.[2]	Unsatisfactory	Do.
10	Coleraine	Nov. 6, 1912	Mine drifts	Private	do.[2]	Satisfactory	Do.
11	Crookston	Aug. 13, 1913	Drilled wells and Red Lake River.[4]	do	Satisfactory	do	Given.
12	Currie	Nov. 3, 1913	Drilled well	Municipal	Unsatisfactory [2]	do	Refused.
13	Deer River	July 24, 1913	do	Railroad	Satisfactory	do	Given.
14	Duluth	July 3, 1913	Lake Superior [6]	Municipal	do	do	Do.
15	East Grand Forks	Aug. 13, 1913	Red Lake River [4]	do	Unsatisfactory [2]	Unsatisfactory	Refused.
16	Ellsworth	Nov. 5, 1913	Dug well	Railroad	do.[5] [3] [2]	do	Do.
17	Elmore	Nov. 7, 1913	Drilled well	Municipal	do.[2]	Satisfactory	Do.
18	Ely	June 5, 1913	Long Lake [7]	do	do.[2]	Unsatisfactory	Do.
19	Eveleth	Nov. 12, 1912	St. Marys Lake [8]	do	Satisfactory	Satisfactory	Given.
20	Eyota	Nov. 14, 1913	Drilled well	Railroad	Unsatisfactory [2]	do	Refused.
21	Glencoe	Dec. 17, 1913	do	do	Satisfactory	do	Given.
22	Glenwood	Oct. 1, 1913	do	do	do	do	Do.
23	Grand Rapids	July 24, 1913	Hay Lake [1]	Municipal	Unsatisfactory [3] [2]	Unsatisfactory	Refused.
24	Hayfield	Nov. 8, 1913	Drilled well	Railroad	Satisfactory	Satisfactory	Given.
25	Hull Rust Yards	June 7, 1913	Dug well	do	Unsatisfactory [2]	do	Refused.
26	Jasper	Nov. 6, 1913	Springs	Municipal	Unsatisfactory [5] [3] [2]	Unsatisfactory	Do.
27	Knife River	June 3, 1913	Drilled well	Railroad	Unsatisfactory [2]	Satisfactory	Do.
28	Little Falls	Jan. 19, 1914	Mississippi River	Private	Satisfactory	do	Given.
29	Mankato	Oct. 10, 1913	Drilled wells	Municipal	do	do	Do.
30	Mitchell	June 7, 1913	Drilled well	Railroad	Unsatisfactory [2]	do	Refused.
31	Montevideo	Oct. 6, 1913	Springs	Municipal	Satisfactory	do	Given.
32	Morris	Oct. 2, 1913	Drilled wells	do	do	do	Do.
33	Mountain Iron	June 7, 1913	Mine shaft and drill points	do	Unsatisfactory [2]	do	Refused.
34	New Ulm	Oct. 9, 1913	Drilled wells	do	Satisfactory	Unsatisfactory	Do.
35	Northfield	July 11, 1913	Drilled well	do	Unsatisfactory [2]	Satisfactory	Do.
36	Ortonville	Oct. 4, 1913	Dug well	Railroad	Satisfactory	Satisfactory	Given.
37	Pipestone	Nov. 6, 1913	Drilled well	do	do	do	Do.
38	Plainview	Nov. 14, 1913	Drilled wells	Municipal	Unsatisfactory [2]	do	Refused.
39	Pokegama Springs	Aug. 11, 1913	Spring	Private	Satisfactory	do	Given.

40	Rainy Junction	June 6, 1913	Dug well	Railroad	Unsatisfactory [5] [2]	Unsatisfactory	Refused.
41	Redby	June 12, 1913	Drilled well	do	Unsatisfactory [2]	Satisfactory	Do.
42	Redwood Falls	Oct. 9, 1913	Dug well	do	Unsatisfactory [5] [3] [2]	Unsatisfactory	Do.
43	Rochester	Nov. 15, 1913	Dug wells	Private	Satisfactory	Satisfactory	Given.
44	Rush City	July 21, 1913	Dug well	do	Unsatisfactory [5] [3] [2]	Not examined	Refused.
45	St. James	Nov. 3, 1913	Drilled wells	Municipal	Unsatisfactory [2]	Satisfactory	Do.
46	Sanborn	Oct. 7, 1913	Dug well	Private	Unsatisfactory [5] [3] [2]	Unsatisfactory	Do.
47	Sandstone	July 26, 1913	Drilled well	do	Satisfactory	Satisfactory	Given.
48	Sleepy Eye	Oct. 8, 1913	Drilled wells	do	do	do	Do.
49	Staples	Aug. 11, 1913	Dower Lake,[1] drilled wells	Railroad	Unsatisfactory [5] [3] [2]	Unsatisfactory	Refused.
50	Stillwater	July 23, 1913	Spring and drilled well	Municipal	Satisfactory	Satisfactory	Given.
51	Tracy	Oct. 7, 1913	Drilled well	do	do	do	Do.
52	Two Harbors	June 3, 1913	Lake Superior [6]	do	do	do	Do.
53	Vesta	Oct. 8, 1913	Dug well	Railroad	Unsatisfactory [5] [2]	Unsatisfactory	Refused.
54	Virginia	June 6, 1913	Drilled wells	Private	Satisfactory	Satisfactory	Given.
55	White Bear	July 22, 1913	Drilled well	Railroad	Unsatisfactory [2]	do	Refused.
56	Willmar	Oct. 3, 1913	do	do	Satisfactory	do	Given.
57	Winona	Nov. 13, 1913	Driven well	do	do	do	Do.
58	Worthington	Nov. 4, 1913	Drilled wells	Municipal	do	do	Do.
58	Worthington	do	Dug well	Railroad	Unsatisfactory [5] [3] [2]	Unsatisfactory	Refused.
59	Wyoming	July 21, 1913	Driven well	do	Unsatisfactory [2]	Satisfactory	Do.
60	Zumbrota	Nov. 15, 1913	Drilled well	Municipal	do	do	Do.

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[1] No form of purification.
[2] Construction faulty (may refer to well, purification plant, etc.).
[3] Environment unsatisfactory.
[4] Filtration and hypochlorite treatment.
[5] Location improper for type.
[6] Hypochlorite treatment only.
[7] Filtration only.
[8] Lake patroled by sanitary police.

TABLE 4.—*Bacteriological results on supplies investigated.*

Supply No.	Representing water collected from—	Bacteria per cc.	B. coli.	
			1 cc.	100 cc.
1	Drilled well	2	0	0
	Distribution system	0	0	0
2	Whiskey Creek	200	+	+
	Distribution system	170	+	+
3	Drilled well No. 1	145	0	0
	Drilled well No. 2	40	0	0
	Driven wells	575	0	0
	Distribution system	60	0	0
4	.....do	50	0	0
5	Spring	5	0	0
6	Ottertail River	2,800	+	+
	Filter effluent	19	0	0
	.....do	16	0	0
	Distribution system	160	0	0
7	Dug well	19	0	+
	Storage reservoir	30	0	+
	Distribution system	145	0	+
8	Drilled well	1,400	0	0
9	Springs	40	0	+
	Distribution system	35	0	+
	.....do	35	0	+
10	Mine drifts Nos. 2 and 30	35	0	0
	Mine drift No. 9	80	0	0
	Storage sump	35	0	0
	Distribution system	80	0	0
	.....do	35	0	0
11	Drilled well No. 1	8	0	0
	Drilled well No. 2	23	0	0
	Drilled well No. 3	7	0	0
	Red Lake River	240	+	+
	Effluent filter No. 1	70	0	0
	Effluent filter No. 2	10	0	0
12	Pressure tank	360	0	0
	Distribution system	170	0	0
13	Drilled well	1	0	0
14	Pumping station [1]	12	0	0
	Distribution system [1]	22	0	0
15	Red Lake River	750	+	+
	Sedimentation basin	150	0	+
	Effluent filter No. 1	950	0	+
	Effluent filter No. 2	3,500	0	+
	Distribution system	....	0	+
16	Dug well	450	0	+
17	Drilled well	1	0	0
	Distribution system	3	0	0
18	Long Lake	2,200	0	+
	Filter effluent	1,300	0	+
	Distribution system	1,700	0	+
	.....do	1,600	0	+
19	St. Mary's Lake	3	0	0
	Distribution system	16	0	0
	.....do	55	0	0
20	Drilled well	45	0	0
	Distribution system	53	0	0
21	Drilled well	50	0	0
	Distribution system	40	0	0
22	Drilled well	40	0	0
	Distribution system	8	0	0
23	Hay Lake	120	0	0
	Distribution system	125	0	0
	.....do	160	0	0
24	Drilled well	6	0	0
	Distribution system	1	0	0
25	Dug well	850	0	0
	Distribution system	80	0	0
26	Springs	30	0	0
	Distribution system	60	0	+
27	Drilled well	450	0	0
28	Mississippi River	430	0	+
	Distribution system	335	0	0
	.....do	9	0	0
	.....do	9	0	0
29	Drilled wells	2	0	0
	Distribution system	3	0	0
30	Drilled well	8	0	0
	Distribution system	10	0	0
31	Springs	15	0	0

+=B. coli found. 0=B. coli not found.

[1] Average daily (except Sunday) examinations during April, 1913.

TABLE 4.—*Bacteriological results on supplies investigated*—Continued.

Supply No.	Representing water collected from—	Bacteria per cc.	B. coli.	
			1 cc.	100 cc.
32	Drilled wells	7	0	0
	Distribution system	3	0	0
	.....do	5	0	0
33	Mine shaft and drill points	215	0	0
	Distribution system	300	0	0
34	Drilled well No. 1	3	0	0
	Drilled well No. 2	30	0	0
	Drilled well No. 3	125	0	+
	Distribution system	25	0	0
35	Drilled well	3	0	0
	Distribution system	3	0	0
	.....do	2	0	0
36	Dug well	17	0	0
	Distribution system	11	0	0
37	Drilled well	50	0	0
	Distribution system	45	0	0
38	Drilled well No. 1	7	0	0
	Drilled well No. 2	44	0	0
	Distribution system	4	0	0
39	Springs	10	0	0
	Effluent filter No. 5	3	0	0
40	Dug well	1,350	0	+
41	Drilled well	140	0	0
	Distribution system	2,500	0	0
42	Dug well	97,000	+	+
43	Dug wells	5	0	0
	Distribution system	2	0	0
45	Drilled well No. 1	28	0	0
	Drilled well No. 2	80	0	+
	Distribution system	9	0	0
46	Dug well	1,150	0	0
47	Drilled well	7	0	0
	Distribution system	3	0	0
	.....do	1	0	0
48	Drilled well	12	0	0
	Distribution system	1,700	+	+
49	Dower Lake	325	0	0
	Distribution system	375	0	+
50	Drilled well	1	0	0
	Spring	36	0	0
	Distribution system	83	0	0
	.....do	12	0	0
	.....do	21	0	0
51	.....do	1	0	0
52	Lake Superior	35	+	+
	Distribution system	4	0	0
	.....do	5	0	0
	.....do	7	0	0
53	Dug well	250	0	+
54	Drilled wells	10	0	0
	Distribution system	15	0	0
	.....do	50	0	0
55	Drilled well	120	0	0
	Distribution system	190	0	0
56	Drilled well	1	0	0
	Distribution system	185	0	0
57	Driven well	9	0	0
58	Drilled well No. 3	17	0	0
	Drilled well No. 4	14	0	0
	Drilled wells Nos. 3 and 4	6	0	0
	Distribution system	6	0	0
	Dug well	1,450	0	+
59	Driven well	160	0	0
60	Drilled well	13	0	0
	Distribution system	1	0	0
	.....do	12	0	0

+ = B. coli found. 0 = B. coli not found.

TABLE 5.—*Physical and chemical results on supplies investigated.*

Supply No.	Representing water collected from—	Physical examination.			Total hardness.	Alkalinity.	Incrustants.	Chemical examination.					
		Turbidity.	Color.	Odor 20° C.				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorine.	Iron.
1	Drilled well	15	45	0	338	356	0.0	0.062	1.200	0.0	Trace.	3.5	1.40
2	Whiskey Creek	15	35	v 2	323	320	9.2	.222	.184	.003	Trace.	3.5	.0
3	Driven wells	20	34	d 1	189	204	.0	.060	.182	.0	0.0	3.5	1.40
4	Distribution system	0	15	e 1	186	220	.0	.022	.044	.0	.0	7.5	Trace.
5	Spring	8	138	v 1	106	96	10.0	.462	.072	.0	.0	3.5	.20
6	Ottertail River	60	55	e 3	171	200	.0	.364	.060	Trace.	.120	2.8	.40
7	Storage reservoir	5	10	d 1	593	428	165.0	.068	.320	Trace.	.40	6.5	.40
8	Drilled well	0	0	0	255	236	19.0	.120	.032	Trace.	3.20	4.5	1.80
9	Springs	0	30	0	301	80	221.0	.086	.028	Trace.	.0	2.5	.40
10	Distribution system	0	9	e 1	101	244	.0	.028	0.50	Trace.	.0	1.5	.0
11	Red Lake River	50	60	v 1	178	156	22.0	.350	.052	.0	.0	2.5	Trace.
12	Pressure tank	30	36	0	588	296	292.0	.152	2.220	Trace.	.28	4.5	3.00
13	Drilled well	0	10	s 1	404	284	120.0	.038	.680	.0	Trace.	5.5	Trace.
14	Lake Superior[1]	0	0	0	46	48	.0	.058	.004	.0	.08	2.0	.0
15	Red Lake River	40	50	v 1	185	164	21.0	.374	.048	.0	.0	7.5	.0
16	Dug well	5	11	e 1	600	416	184.0	.086	.036	.001	20.0013	6.0	.40
17	Drilled well	3	30	p 1	321	396	.0	.070	.694	.0	.080	5.5	.40
18	Long Lake	10	63	v 2	16	24	.0	.254	.052	Trace.	.0	1.8	.40
19	St. Marys Lake	2	24	m 2	11	20	.0	.196	.016	.0	.0	1.5	.0
20	Drilled well	0	0	0	228	196	32.0	.068	.016	Trace.	2.80	4.5	1.00
21	.....do	10	40	e 1	185	342	.0	.076	1.340	.0	.0	9.5	1.60
22	.....do	0	0	d 1	265	224	41.0	.012	.004	.003	1.60	10.0	.0
23	Hay Lake	0	10	v 1	346	128	218.0	.134	.050	.0	Trace.	3.5	.0
24	Drilled well	15	40	e 1	238	260	.0	.042	.548	.0	Trace.	3.5	1.4
25	Dug well	20	45	d 1	106	128	.0	.042	.104	.0	.0	2.5	.6
26	Springs	0	0	e 1	213	208	5.0	.040	.032	.0	2.40	11.0	.0
27	Drilled well	0	12	e 1	589	248	341.0	.154	.020	.005	25.60	218.0	.2
28	Mississippi River	2	70	v 2	148	168	.0	.244	.050	.0	.20	4.5	Trace.
	Distribution system	2	68	v 2	155	164	.0	.252	.060	.0	.20	3.5	Trace.
29	Distribution system[2]	5	20	d 1	375	312	63.0	.120	1.660	0.0	0.0	15.5	1.80
30	Drilled well	40	96	a 1	134	180	.0	.044	.032	.0	.08	6.5	5.00
31	Springs	10	34	a 1	510	348	162.0	.060	.024	.0	.0	4.5	1.40
32	Drilled wells	20	58	e 1	493	300	193.0	.032	.104	.0	.0	2.5	2.00
33	Mine shaft and drill points	3	15	e 1	175	164	11.0	.030	.018	Trace.	.16	15.0	.40
34	Drilled well	10	24	e 1	336	280	56.0	.104	2.700	Trace.	.0	129.0	.60
35	.....do	15	30	e 1	309	328	.0	.048	.228	Trace.	.0	3.5	2.00
36	Dug well	40	34	e 1	573	408	165.0	.052	.152	.0	.12	7.0	1.00

37	Drilled well	3	9	e 1	393	200	193.0	.036	.024	.0	1.48	14.0	.0
38	.....do	0	0	e 1	225	220	5.0	.074	.038	.0	.28	7.0	.40
40	Dug well	5	20	d 2	104	100	4.0	.086	.020	0.005	2.80	3.3	.80
41	Drilled well	0	34	0	266	340	.0	.062	.650	.0	.0	4.5	.20
42	Dug well	0	9	e 1	553	288	265.0	.068	.038	.0	1.20	36.0	.0
43	.....do	0	10	0	243	224	19.0	.254	.166	0.001	3.20	7.0	.40
45	Drilled well No. 2	63	53	0	575	400	175.0	.182	2.510	0.010	.40	9.0	18.00
46	Dug well	0	Trace.	e 1	578	424	154.0	.078	.034	.0	2.80	95.0	Trace.
47	Drilled well	0	0	0	284	56	228.0	.020	.024	.0	Trace.	4.5	Trace.
48	.....do	20	58	0	485	436	49.0	.094	1.840	.0	.0	4.5	4.00
50	.....do	0	0	e 1	186	192	.0	.034	.014	.0	.80	7.0	.0
51	Distribution system	50	33	e 1	580	292	288.0	.112	.890	.0	Trace.	4.5	5.00
52	Lake Superior	0	5	0	24	40	.0	.100	.022	.0	0.20	2.5	.0
53	Dug well	0	0	e 1	263	156	107.0	.030	.032	.0	2.00	6.5	Trace.
54	Drilled wells	0	5	d 1	209	240	.0	.026	.036	.0	.0	4.5	.0
55	Drilled well	0	0	e 1	176	192	.0	.048	.368	0.003	1.60	9.0	Trace.
58	Drilled wells Nos. 3 and 4	40	30	0	575	316	259.0	.118	1.000	Trace.	.08	5.5	5.0
	Driven well	8	45	e 1	228	224	4.0	.022	.020	Trace.	.40	5.5	.0
59	.....do	0	0	e 1	174	176	.0	.052	.020	.0	1.00	3.3	.0
60	Drilled well	5	25	e 1	253	252	1.0	.258	.132	Trace.	.0	2.5	.60

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[1] Analysis of water made Aug. 11, 1910.

[2] Analysis of water made July 26, 1911.

From Table 3 it will be seen that a great variety of sources of water supply are used by the railroads in providing drinking water for the traveling public in Minnesota. Although the number of investigations made at this time is too small to afford any basis for drawing general conclusions, nevertheless some very interesting data become available. Rearranging the results and tabulating them according to the types of supply will bring plainly into view some of these interesting facts.

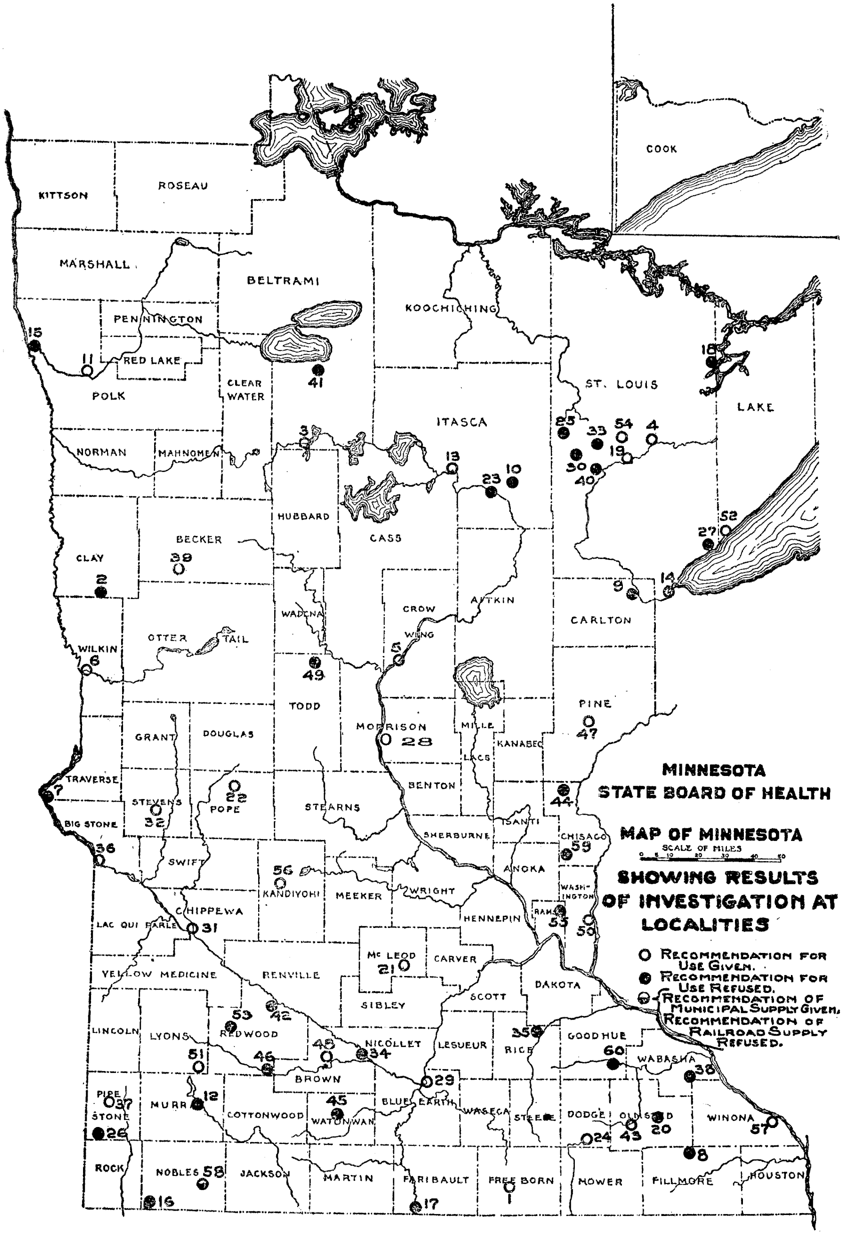
TABLE 6.—*Results according to types of supply.*

Type of supply.	Field investigation.				Analytical results.		Recommendation for use—	
	Number investigated.	Number satisfactory.	Number unsatisfactory.	Reason why unsatisfactory.	Number satisfactory.	Number unsatisfactory.	Given.	Refused.
Underground.								
Wells:								
Dug	[1] 11	2	9	a,b= 1 a,b,c= 5 c= 1 a,c= 2	3	7	2	9
Drilled	29	17	12	c=12	28	1	16	13
Driven	2	1	1	c= 1 a,b,c= 1	2	0	1	1
Springs	5	3	2	c= 1	3	2	3	2
Mine drifts	1	0	1	c= 1	0	1	0	1
Mine shafts and drill points	1	0	1	c= 1	0	1	0	1
	49	23	26	26	36	12	22	27
Surface.								
Lakes	5	3	2	b= 1 c= 1	3	2	3	2
Rivers	3	2	1	c= 1	2	1	2	1
Creek	1	0	1	b= 1	0	1	0	1
	9	5	4	4	5	4	5	4
Combined.								
Drilled wells and river	1	1	0	0	1	0	1	0
Drilled wells and lake	1	0	1	a,b,c= 1	0	1	0	1
Drilled wells and spring	1	1	0	0	1	0	1	0
	3	2	1	1	2	1	2	1
Total	61	30	31	31	43	17	29	32

[1] Analytical results were not obtained in one instance.

a. Location improper for type.
b. Environment unsatisfactory.
c. Construction faulty (may refer to well, purification plant, etc.).

Table 6 is a digest of Table 3, and indicates the number of each variety of supply that has been found and the results which were obtained by field and analytical investigation. There is indicated also whether or not recommendations for use were given. It becomes apparent that of the 61 supplies investigated, 49 were of the underground variety, 9 of the surface variety and 3 were a combination of surface and underground supplies. This is in conformity with the general usage throughout the State where for the most part underground water supplies are used. In certain localities the underground waters on account of their high mineral content or for other reasons may be unfitted for drinking purposes, and it then becomes necessary to adopt some other form of supply. In a few localities where underground sources are used for water supply and where the supply is to a certain extent limited, extra connections with the surface supply are installed for fire protection purposes. These are noted in the detailed reports of the localities in which they appear.



MAP NO. 2.

In 6 of the surface supplies investigated some form of purification or treatment is employed. These are indicated in Table 3 and are also noted in the detailed reports of the localities.

A most interesting fact is well brought out on examining Table 6 If analytical results alone were depended upon to determine the sanitary value of these water supplies, 43 would have been found satisfactory and 17 unsatisfactory. On the other hand, when the field investigation is also taken into consideration, only 29 are satisfactory while 32 are unsatisfactory. The geographical distribution of these is shown in map No. 2. As a matter of fact, in only one instance was a water supply condemned on account of analytical results alone, and in this particular case a complete field investigation was impossible on account of the construction of the well involved.

These figures bring prominently into view the large amount of importance that should be placed on the field investigation which should be undertaken by an individual specially trained in this line of work. As a result of taking both field and analytical findings into consideration 29 supplies were given and 32 were refused recommendation. It should be understood that in many cases refusal to recommend a supply was based not on finding actual evidences of pollution, but upon finding avenues through which pollution might gain entrance to the supply. These have been roughly divided into three classes: (*a*) Location faulty for the particular type involved; (*b*) environment unsatisfactory, showing that it would menace the present or future safety of the supply; (*c*) construction of the system faulty, showing means by which pollution could enter. This might refer to the improper construction of the apparatus already installed or to a lack of devices for adequately protecting or treating the supply. The frequency with which these general factors occur is shown in Table 7. An analysis of this table shows that faulty construction is the factor which most frequently occurred. This is very important from a sanitary viewpoint, inasmuch as defects can be readily remedied, thereby putting the supply in a sanitary condition—another evidence of the value of a field investigation.

TABLE 7.—*Summary of predominating unsatisfactory features of supplies.*

Predominating unsatisfactory features.	Feature appears alone.	In conjunction with others.	Total.
a............	0	10	10
b............	2	10	12
c............	19	11	30

While the number of supplies on which recommendation was refused on account of the field investigation may be considered large, it should be remembered that this investigation was very thorough for the purpose of bringing to light any possible means by which pollution might enter the system. A careful study shows without a doubt that many of these defects could be rectified easily and at a comparatively low cost, thereby converting an unsafe water supply into a safe one. Doubtless in many instances the defects were either unknown or their dangers not appreciated by the owners of the supply. Inasmuch as in each case the attention of the owner of the supply has been drawn to the defects which rendered that particular supply unfit for public consumption, by means of a full and complete statement of the facts in a formal report, together with recommendations whereby the supply may be corrected, it is confidently expected that these defects will be speedily remedied. Since many of these are municipal supplies, great benefit will be derived not only to the traveling public but also to the citizens of the municipality using the supply.

Summary.

1. The results of this investigation show that over 50 per cent (52.45 per cent) of the supplies investigated could not be recommended in their present state as drinking water supplies.
2. Of the 32 supplies on which recommendation was refused, 31 were pronounced unsafe by the field investigation and of these but 16 showed analytical evidence of pollution. In one instance only did the analytical results alone constitute the refusal for recommendation.
3. A careful and adequate field investigation in addition to the analytical determinations is required before a satisfactory opinion should be ventured concerning the safety of a given water supply.
4. The owners of practically all the condemned water supplies can convert these into safe supplies at a relatively small cost by following in detail the recommendations given each locality.